

AG Contract No. KR99 2541TRN
ADOT ECS File: JPA 99-177
Project No. SPR-495
TRACS No.: R0495 11P
Research: Particulate Emissions from Major
Valley Roadways Study

INTERAGENCY AGREEMENT
BETWEEN
THE DEPARTMENT OF TRANSPORTATION
AND
THE ARIZONA STATE UNIVERSITY

THIS AGREEMENT is entered into 17 November, 1999, between agencies of the State of Arizona, to wit; the DEPARTMENT OF TRANSPORTATION (the "DOT") and the ARIZONA BOARD OF REGENTS, acting for and on behalf of ARIZONA STATE UNIVERSITY, (the "University").

I. RECITALS

1. The DOT is empowered by Arizona Revised Statutes Section 28-401 to enter into this agreement and has by resolution, a copy of which is attached hereto and made a part hereof, resolved to enter into this agreement and has delegated to the undersigned the authority to execute this agreement on behalf of the DOT.

2. The University is empowered by Arizona Revised Statutes Section 15-1626 to enter into this agreement and has delegated to the undersigned authority to execute this agreement on behalf of the University.

3. The DOT and the University desire to conduct research and develop a field study report of particulate emissions from major roadways in the Phoenix airshed, all in accordance with Exhibit A which is attached hereto and made a part hereof, at an estimated total cost of up to \$300,000.00, all at DOT expense, hereinafter referred to as the Project.

THEREFORE, in consideration of the mutual agreements expressed herein, it is agreed as follows:

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II. SCOPE OF WORK

1. The DOT will:
 - a. Appoint a Project coordinator within the DOT's Transportation Research Center to interface with the University relating to the research and development
 - b. Provide the University with information and data as may be reasonably available to assist in the Project research and development.
 - c. Reimburse the University within forty-five (45) days after receipt and approval of monthly invoices, in a total amount currently estimated at up to \$300,000.00.

2. The University will:
 - a. Appoint a Project coordinator at the University (ASU) to interface with the DOT relating to the research and development.
 - b. Accomplish the research and development of the field study generally in accordance with Exhibit A, which is attached hereto and made a part hereof, provide the DOT with appropriate progress reports, and a final report documenting the program, data derived, and the final results. Such reports will be in a format compliant with the DOTs "Guidelines for Preparing Research Reports."
 - c. No more often than monthly, invoice the DOT in the form of Exhibit B attached hereto, supported by narrative progress reports and an accounting of monthly costs and expenditures on the Project. Upon completion of the Project, provide the DOT with a detailed final report.

III. MISCELLANEOUS PROVISIONS

1. Title to all documents, reports and other deliverables prepared by the University in performance of this agreement shall rest jointly with the DOT and the University.
2. This agreement shall become effective upon signature by the parties hereto, and shall remain in force and effect until completion of said Project and reimbursements; provided, however, that this agreement, may be cancelled at any time prior to the commencement of performance under this agreement, upon thirty (30) days written notice to the other party.
3. The parties agree to comply with all applicable state and federal laws, rules, regulations and executive orders governing equal employment opportunity, immigration, nondiscrimination and affirmative action.
4. This agreement may be cancelled in accordance with Arizona Revised Statutes Section 38-511.
5. The provisions of Arizona Revised Statutes Section 35-214 are applicable to this contract.
6. In the event of any controversy which may arise out of this agreement, the parties hereto agree to abide by required arbitration as is set forth for public works contracts in Arizona Revised Statutes Section 12-1518.

7. All notices or demands upon any party to this agreement relating to the agreement shall be in writing and shall be delivered in person or sent by mail addressed as follows:

Department of Transportation
Joint Project Administration
205 S. 17th Avenue - 616E
Phoenix, AZ 85007

Arizona State University
Research & Creative Act.
PO Box 871603
Tempe, AZ 85287-1603

8. The parties recognize that performance by ASU under this Agreement may be dependent upon the appropriation of funds by the State Legislature of Arizona. Should the Legislature at any time fail to appropriate the necessary funds for such performance, the, by written notice to the DOT, ASU may cancel this Agreement.

IN WITNESS WHEREOF, the parties have executed this agreement the day and year first above written.

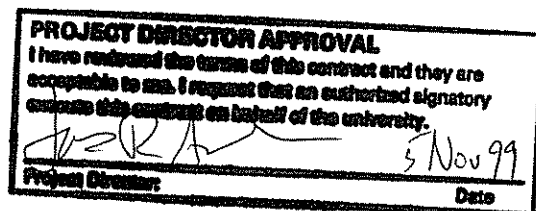
STATE OF ARIZONA

THE ARIZONA BOARD OF REGENTS DEPARTMENT OF TRANSPORTATION
acting for and on behalf of
ARIZONA STATE UNIVERSITY

By Janice D. Bennett
JANICE D. BENNETT, Director
Office of Research and
Creative Activities 11-10-97

By Victor M. Menendez
VICTOR MENDEZ
Deputy Director 11-17-99

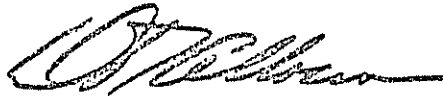
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RESOLUTION

BE IT RESOLVED on this 28th day of September 1999, that I, the undersigned MARY E. PETERS, as Director of the Arizona Department of Transportation, have determined that it is in the best interests of the State of Arizona that the Department of Transportation, acting by and through the Intermodal Transportation Division, to enter into an agreement with Arizona State University for the purpose of defining responsibilities for conducting a particulate emissions study.

Therefore, authorization is hereby granted to draft said agreement which, upon completion, shall be submitted to the Deputy Director for approval and execution.


A handwritten signature in dark ink, appearing to read 'D. Allocco', written over a horizontal line.

DAVID R. ALLOCCO, P.E.
Assistant State Engineer
Engineering Technical Group
for Mary E. Peters, Director

APPROVAL OF ARIZONA STATE UNIVERSITY ATTORNEY

I have reviewed the above referenced proposed interagency agreement, between the DEPARTMENT OF TRANSPORTATION, HIGHWAYS DIVISION and the ARIZONA STATE UNIVERSITY, and declare this agreement to be in proper form and within the powers and authority granted to the University under the laws of the State of Arizona.

DATED this 9 day of Nov., 1999.



Attorney for ASU

Research Project Title:

A Field Study of Particulate Emissions from Major Roadways in the Phoenix Airshed.

J. Anderson, J. Fernando, N. Berman, T. Sharp
Environmental Fluid Dynamics Program, Arizona State University

Problem Description:

The new EPA standard for particulate matter focuses on the size range of particles that are easily respired and retained within human lungs, 0.1 to 2.5 microns in diameter (PM_{2.5}). Our current knowledge of particle emissions from transportation-related sources is based primarily on the existing PM₁₀ standard, a measure of the mass of particles smaller than 10 microns (there is abundant statistical evidence that high PM₁₀ levels also affect human health). PM₁₀ is dominated by the larger particles, so that current understanding of the contributions of transportation-related sources to PM₁₀ is not applicable to PM_{2.5}. Future transportation models that predict ambient particle concentrations will have to incorporate both PM₁₀ and the new PM_{2.5} standard. Because large variations in emission factors occur because of variables like climate, roadway type, and vehicle type and conditions, generic emission factors from other regions or laboratory studies will not suffice. Accurate modeling of the Phoenix urban area requires direct measurement of particulates, their compositions, size distributions, and concentrations and accompanying meteorological conditions along and away from major roadways. Measurements of particulates, both PM₁₀ and PM_{2.5}, must be accompanied by accurate counts of vehicle numbers, types, and their speeds.

A significant challenge in a field study of roadway emissions is separation of the urban regional plume from the freeway emissions. A second challenge is distinguishing particles re-entrained off the road surface from vehicle exhaust particles. The extent to which re-entrained particles and vehicle exhaust particles are aggregated together is an unknown that presents a further challenge. The experimental design must address these problems.

There is a serious disparity between receptor-model and emission-inventory estimates of the contribution that combustion sources make to fine particulates. For the Phoenix area, receptor models estimate that 70% of primary fine particulates come from combustion. In contrast, emission inventories estimate that 18% come from combustion. Part of the disparity is due to an underestimation of PM_{2.5} from vehicular exhaust coupled with possible overestimates of re-entrained dust. More of the disparity may stem from a lack of knowledge of the composition of re-entrained dust, which may consist of aggregates of soil particles with carbonaceous material rather than just soil particles alone. A field study that combines traditional mass aerosol methods with state-of-the-art single-particle methods is the best way to improve our understanding of the problem. The accurate evaluation of any fine particulate control strategy cannot proceed without our knowledge of the different contributing particle fractions.

Although roadway-derived particulates ultimately add to the ambient urban aerosol, the most severe potential impacts of re-entrained dust on human health are in residential areas within

close proximity to major roadways with significant heavy truck traffic. Little is known about the downwind concentrations of roadway dust in complex terrain areas of the Southwest like Phoenix.

Research Objectives:

1. To determine PM_{2.5} and PM₁₀ emissions factors for total vehicle-related particulates on major roadways in the Phoenix urban airshed;
2. To determine PM_{2.5} and PM₁₀ emissions factors for re-entrainment of mineral dust particles from major roadways including data by vehicle type and speed so as to assess the impact on the ambient urban aerosol;
3. To determine the downwind contributions of roadway particles to PM_{2.5} and PM₁₀ at distances of up to 1 km so as to assess the local impact of freeways on adjacent residential areas;
4. To determine whether re-entrained mineral dust is aggregated with significant amounts of carbonaceous material.

Research Tasks:

1. Sample and analyze particulates using EPA-approved PM_{2.5} and PM₁₀ mass samplers on freeway medians at either existing ADOT traffic-counting locations or co-located with special counters. Place a set of samplers on each side of the freeway so that upwind and downwind aerosol can be distinguished. Identical sets of sampling instruments will be used, each mounted in mobile enclosures (instruments are listed below).
2. Use identical instruments mounted in a mobile enclosure to measure PM_{2.5} and PM₁₀ in adjacent residential areas up to 1 km downwind of the freeway.
3. Use the following methods for aerosol mass:
 - a. Tapered Element Oscillating Microbalance (TEOM), EPA equivalency for PM₁₀ EQPM-1090-079 (measures mass of PM₁₀ continuously).
 - b. Sequential filter sampler attachment to TEOM for collection of PM₁₀ for PIXE analysis (chemical composition of PM₁₀).
 - c. Sequential PM_{2.5} filter sampler, EPA reference method RFPS-0498-118 (samples used for both mass and chemical composition of PM_{2.5}).
 - d. Andersen dichotomous PM₁₀/PM_{2.5} filter sampler, EPA reference method RFPS-0789-073 (for direct comparison with ADEQ 24-hour aerosol data).
4. Quantitative single-particle analysis of inorganic particles by automated scanning electron microscope (SEM). Determine the chemically distinct types of particles present, their number concentrations, and the size distributions for each particle type. This method will allow determination of the loading of re-entrained soil dust.
5. Examination of particle structure, morphology, and composition by manual transmission electron microscopy (TEM). This will determine the degree of aggregation of mineral particles with soot and also examine if there are morphological differences between soil particles re-entrained from freeway surfaces and soil particles from other sources. Both SEM and TEM will cover the size range of 0.1 to 10 microns, from which the equivalent of both PM_{2.5} and PM₁₀ can be extracted. Both methods will use samplers collected with Programmable Streaker Samplers (PIXE International).
6. Measure the temperature, relative humidity, wind speed (down to 0.5 m/s), and wind direction at the three sites (T and RH also necessary for aerosol mass calibration).
7. From the data collected in the above tasks, calculate PM₁₀ and PM_{2.5} emission factors for re-entrained soil dust with regard to vehicle type and speed. Determine the relationships between

source strength of re-entrained dust, wind speed, distance from source, and other variables that determine the downwind impact of freeway aerosols on adjacent neighborhoods

Budget: \$295,000

Duration: 18 months (November 1999 through April 2001)

Summary timeline:

1. December 1999, purchase needed equipment and install in mobile enclosures
2. Early January 1999, field test sampling systems
3. November/December 1999, select freeway sampling site(s) in coordination with ADOT and ADEQ
4. Mid-January through February 2000, conduct winter experiment with the goal of obtaining at least 14 days of samples under high-pollution conditions (terrain-controlled thermally-driven surface winds with little influence from synoptic winds)
5. March 2000 to end of project, analyze samples from winter experiment
6. Mid-May through June 2000 (or until monsoon begins), conduct summer experiment with the goal of obtaining at least 14 days of samples under wind conditions similar to those above
7. July 2000 through end of project, analyze samples from summer experiment
8. November 2000 through April 2001, write report of results

DETAIL TASKS LIST

Task 1 – Field project planning and selection of field sites in coordination with the Technical Advisory Committee (TAC) A kick-off meeting with the TAC will be held for this purpose

Task 2 – Purchase equipment and three mobile enclosures (utility trailers), then modify mobile enclosures for field deployment and mount equipment in them. Equipment that needs to be purchased is in response to requests by the TAC for specific types of data in addition to those originally planned. Equipment is actually part of Tasks 4 & 8, but needs to be purchased at the start of the project.

Task 3 – Field test equipment before deployment.

Task 4 –Conduct winter field experiment. Over the period of mid-January through February 2000, collect at least 14 days worth of samples of the following type: average PM10 every hour using TEOMs; filter samples for bulk PM10 composition by PIXE every 2 to 3 hours using sequential filter attachment to TEOMs; sequential filter samples for PM2.5 mass and chemical composition every 2 to 3 hours; dichotomous filter samples for PM10 and PM2.5 every 12 to 24 hours; single-particle samples on Nuclepore filters and TEM grids using Programmable Streaker Samplers every hour; temperature, relative humidity, wind direction, and wind speed every minute

Task 5 –Analyze selected samples for (a) aerosol mass, (b) aerosol chemical composition by PIXE analysis, (c) single-particle size, composition, and number concentration by automated scanning electron microscope, and (d) single-particle morphology and composition by transmission electron microscope. Only samples collected under favorable meteorological conditions will be analyzed.

Task 6 –Evaluate initial results from winter experiment and plan for summer experiment

Task 7 – Conduct summer field experiment. Over the period of mid-May through mid-July 2000, collect at least 14 days worth of samples of the following type: average PM10 every hour using TEOMs; filter samples for bulk PM10 composition by PIXE every 2 to 3 hours using sequential filter attachment to TEOMs; sequential filter samples for PM2.5 mass and chemical composition every 2 to 3 hours; dichotomous filter samples for PM10 and PM2.5 every 12 to 24 hours; single-particle samples on Nuclepore filters and TEM grids using Programmable Streaker Samplers every hour; temperature, relative humidity, wind direction, and wind speed every minute

Task 8 – Analyze selected samples for (a) aerosol mass, (b) aerosol chemical composition by PIXE analysis, (c) single-particle size, composition, and number concentration by automated scanning electron microscope, and (d) single-particle morphology and composition by transmission electron microscope. Only samples collected under favorable meteorological conditions will be analyzed.

Task 9 –Calculate emission factors for total PM10 and PM2.5 from the sampled freeway. Calculate the portion of emitted PM10 and PM2.5 attributable to soil dust re-entrained from roadway surface. Calculate the contribution of roadway aerosol to downwind surface aerosol at distances of up to 1 km from freeway sampling site.

Task 10 –Prepare Draft and Final reports. A draft final report of the entire research effort will be prepared for distribution, review, and comment by ADOT and the other agencies involved in the research through the TAC members. Also, a journal article suitable for publication in

Environmental Science and Technology or similar journal will be prepared subsequent to acceptance of the Final Report.

Task 11. Prepare a Research Note which summarizes the project. This technical summary shall be no more than four pages in length and shall present the project's background, research approach, findings and recommendations. The format for the Research Note is available from the ATRC Librarian.

Task 12. A presentation of the research work and results will be made to (1) the ADOT Research Council, and (2) a technical group of interested parties from the different agencies.

BUDGET

Personnel - overview:

Faculty:

- J. Anderson, 2.0 months effort (1.5 month included in budget)
- J. Fernando, 0.5 month effort (no associated cost in budget)
- N. Berman, 0.5 month effort (no associated cost in budget)
- T. Sharp, 0.5 month effort (no associated cost in budget)

Post-doctoral Fellow : A. Grachev, 12 months effort

Graduate students: 2 @ 50% effort for 12 months

Personnel effort included in budget:

- J. Anderson, 250 hours (@) \$71.25/hour*
- A. Grachev, 2000 hours (@) \$29.91/hour*
- 2 graduate students, total of 2000 hours (@) \$26.02/hour*
- *(includes fringe benefits and overhead)

Equipment

The following items of equipment need to be purchased at the beginning of the project in order to conduct the field experiments. The University does not charge overhead on equipment purchases and there are no costs for use of the equipment included in the budget except for necessary materials and supplies such as filters. Title to the equipment will remain with the University after the project ends so that we can continue to use it for air quality research in Arizona.

Capital equipment: Total = \$137,175.00

- 3 each TEOM PM-10 monitors, EPA equivalency EQPM-1090-079
- 3 each PM-10 multi-filter attachment for TEOMs
- 3 each Sequential PM2.5 filter samplers, EPA reference RFPS-0498-118
- 3 each Andersen dichotomous filter samplers, EPA reference RFPS-0789-073
- 3 each Utility trailers, 6'x10'
- 3 each Wind monitors, 0.4 m/s minimum wind speed

BUDGET BY TASK

Standard University overhead rate is 52.5% and is included in all figures. There is no overhead on equipment.

Task 1:

Budgeted manpower:	J. Anderson	10 hours x \$71.25 =	\$712.50
	A. Grachev	30 hours x \$29.91 =	\$897.30
	Grad. Students	30 hours x \$26.02 =	\$780.60
Mileage on state vehicle			\$228.75
			Total, Task 1 = \$2,619.15

Task 2:

Budgeted manpower:	J. Anderson	10 hours x \$71.25 =	\$712.50
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A. Grachev	120 hours x \$29.91 =	\$3589.20
Grad. Students	120 hours x \$26.02 =	\$3122.40
Capital equipment (see above for description)		\$137,175.00
Materials and supplies		\$1525.00
Total, Task 2 = \$146,124.10		

Task 3:

Budgeted manpower:	J. Anderson	5 hours x \$71.25 =	\$356.25
	A. Grachev	30 hours x \$29.91 =	\$897.30
	Grad. Students	30 hours x \$26.02 =	\$780.60
Mileage on state vehicle			\$76.25
Total, Task 3 = \$2,110.40			

Task 4:

Budgeted manpower:	J. Anderson	50 hours x \$71.25 =	\$3562.50
	A. Grachev	250 hours x \$29.91 =	\$7477.50
	Grad. Students	310 hours x \$26.02 =	\$8066.20
Mileage on state vehicle			\$972.00
Materials and supplies			\$1220.00
Total, Task 4 = \$21,298.20			

Task 5:

Budgeted manpower:	J. Anderson	40 hours x \$71.25 =	\$2850.00
	A. Grachev	440 hours x \$29.91 =	\$13160.40
	Grad. Students	440 hours x \$26.02 =	\$11448.80
Materials and supplies			\$1067.50
Use fees for SEM			\$5556.00
Use fees for TEM			\$2287.50
Use fees for PIXE			\$2058.75
Total, Task 5 = \$38428.95			

Task 6:

Budgeted manpower:	J. Anderson	20 hours x \$71.25 =	\$1425.00
	A. Grachev	120 hours x \$29.91 =	\$3589.20
	Grad. Students	80 hours x \$26.02 =	\$2081.60
Total, Task 6 = \$7,095.80			

Task 7:

Budgeted manpower:	J. Anderson	50 hours x \$71.25 =	\$3562.50
	A. Grachev	250 hours x \$29.91 =	\$7477.50
	Grad. Students	310 hours x \$26.02 =	\$8066.20
Mileage on state vehicle			\$972.00
Materials and supplies			\$1220.00
Total, Task 7 = \$21,298.20			

Task 8:

Budgeted manpower:	J. Anderson	40 hours x \$71.25 =	\$2850.00
	A. Grachev	440 hours x \$29.91 =	\$13160.40
	Grad. Students	440 hours x \$26.02 =	\$11448.80
Materials and supplies			\$1067.50
Use fees for SEM			\$5556.00
Use fees for TEM			\$2287.50

Use fees for PLXE

\$2058.75

Total, Task 8 = \$38,428.95

Task 9:

Budgeted manpower:	J. Anderson	10 hours x \$71.25 =	\$712.50
	A. Grachev	80 hours x \$29.91 =	\$2392.80
	Grad. Students	80 hours x \$26.02 =	\$2081.60

Total, Task 9 = \$5186.90

Task 10:

Budgeted manpower:	J. Anderson	15 hours x \$71.25 =	\$1068.75
	A. Grachev	240 hours x \$29.91 =	\$7178.40
	Grad. Students	160 hours x \$26.02 =	\$4163.20

Total, Task 5 = \$12,410.35

PROJECT TOTAL = \$295,000.50

REPORT REQUIREMENTS:

The Contractor shall provide all deliverables to include, reports and all collected data, to the TAC through the Project Manager

Quarterly (calendar year) Progress Reports shall be submitted at the end of each calendar quarter by the 5th day of the following month (April 5, July 5, October 5, and January 5) during the project term covering the work task performed through the last day of the calendar quarter. At a minimum, these reports must specify project title, period covered, tasks completed, tasks underway, percent of project completed, problems and strategies selected to solve them, and tasks to be performed during the next period.

The Contractor is required to mail one copy of the quarterly report directly to each member of Project TAC. The addresses and names of this Committee will be provided by the Project Manager upon award of contract – with the signing of the project agreement

The following specific information shall be provided:

- 1 Progress Report since the last report.
- 2 Executive Summary of Project: An introduction to the report that consists of a summary of the general problem being researched and the specific objectives applying thereto. Information as appropriate may be taken verbatim from the project statement.
- 3 A concise method of approach including, progress plans and activity schedule shall be completed in this period. This should be detailed enough to indicate clearly the overall accomplishments as related to the scheduled plan of activities. Activity descriptions should be identified with major tasks listed in the progress schedule.
- 4 A Progress Report regarding the activities to be undertaken during the ensuing period. The tasks to be accomplished and any obstacles to accomplishing them, should be discussed.

A Draft Final Report shall be submitted to the Department for review and comment by the Department and the Federal Highway Administration. Sufficient project time should be scheduled for preparation and revision of the final report. Ten copies of the draft final report will be submitted to the Department.

Final Report will be prepared in accordance with the requirements of the "ADOT Guidelines for Preparing ATRC Research Reports", dated February 1996 and the US Department of Transportation Report FHWA-AD-88-001 "Guidelines for Preparing Federal Highway Administration Publications." Both of these documents are available for review, contact Mary Silva, ATRC Librarian, telephone (602) 712-3138. One camera-ready final report, 10 copies of the final report, and an electronic copy of the report will be submitted to the Department.

CONTRACTOR RESPONSIBILITIES

Contractor shall be responsible for the management and coordination activities relating to this project. Task activities shall include, but not be limited to, project administration, record keeping, progress reporting, project scheduling and coordination of all project related meetings.

Accuracy, quality and timeliness of information and product being provided

Acquire all outside data, literature, equipment, etc., needed for this project

Close coordination with the Project Manager to review the progress to date, prepare technical papers, study findings and solicit input

Available to participate in various meetings at the request of the Department

Deliverable products

Participate in review meetings with the Department

Schedule and coordinate meetings with cognizant parties in consultation with Project Manager.

DEPARTMENT RESPONSIBILITIES

Provide a general description of the work required, including, but not limited to, format, frequency and quality of reports, specific areas to be addressed, anticipated project milestones and timelines, etc

Make available all pertinent documents and information.

Review and approve Contractor's working papers and reports

Provide names and addresses of personnel stipulated to receive copies of deliverables, etc

ARIZONA DEPARTMENT OF TRANSPORTATION
Joint Project Administration

[illegible]

Submitted By: _____	Date _____	: Total	:	:
		: To	:	:
		: Date	:	:
Approved By: _____	Date _____	: Total	:	:
ADOT Project Monitor		: Previous	:	:
		: Report	:	:
Approved By: _____	Date _____	:	:	:
		: Current	:	:
		: Report	:	: